National Park Service
U.S. Department of the Interior

Lake Roosevelt
National Recreation Area

Floating Classroom

A Preparation Guide for Eleventh and Twelfth Grades

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Lake Roosevelt National Recreation Area
Coulee Dam, Washington

Produced by Rick Kendall
National Park Service, 2002

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Contents

Though developed to make Americans water-conscious during World War II, this Works Progress Administration poster still holds relevance today. In the Pacific Northwest alone, water is used for drinking, electrical generation, fish habitat, recreation and other purposes. An important message of the Floating Classroom program is to utilize our existing water resources in a manner which promotes sustainability.

Acknowledgements

An overnight learning experience like the Floating Classroom would not be possible without the solid support of the teachers and school districts that participate in the program. Some teachers have been with the program since its inception, others have signed on more recently, but all deserve credit for making the program possible, successful and worthwhile.

The National Park Service provided initial financial support to the Floating Classroom program in the form of a Parks as Classrooms grant which covered much of the initial overhead for testing equipment. Roosevelt Recreational Enterprises has also assisted in the development of the program by offering reduced-rate houseboat rentals and off-season assistance at their marinas. The only way this program could have been successfully launched was with the active cooperation and support of the Washington State Governor's Council on Environmental Education, the Lake Roosevelt Forum, the Washington State Water Resources Center at Washington State University, the Confederated Tribes of the Colville Reservation, the Spokane Tribe of Indians and area schools.

This revised Floating Classroom preparation guide is based roughly upon the previous, five-day curriculum developed by Bradford Frye. As Lake Roosevelt National Recreation Area's first education specialist, Frye was instrumental in initiating the Floating Classroom program and should be credited for much of what the program has become. Interpretive park rangers Jeff Axel, Lynne Brougher, Dan Brown, Dan Hand, and Alex Guier Picavet as well as other National Park Service staff have also played active roles in keeping the program on a course set for excellence.

Students from Wilbur High School test for pH, conductivity, temperature, and dissolved oxygen on a Floating Classroom trip assisted by Jason Maioho, their teacher (standing, in hat).

National Park Service Mission and Core Values

Lake Roosevelt National Recreation Area is one of more than 380 of America's National Parks managed by the National Park Service. The National Park Service preserves unimpaired the natural and cultural resources and values of the national park system for the enjoyment, education, and inspiration of this and future generations. The National Park Service cooperates with partners to extend the benefits of natural and cultural resource conservation and outdoor recreation throughout this country and the world.

To achieve this mission, the National Park Service adheres to the following core values:

Excellence—We continually learn and improve to achieve the highest ideals of public service. In striving to achieve excellence, we encourage and practice proactive behavior, creativity, innovation and vision. This is done both individually and collectively. Through these actions, we meet the vision of the National Park Service mission to serve as caretakers of the premier natural and cultural resources in the United States. We recognize and energetically accept our leadership role in conservation and heritage education.

Integrity—We deal honesty and fairly with the public and one another. We take responsibility for our actions and their consequences. We do so in ways that are ethical and represent the highest standards of public service. Through our actions, we earn the trust of those we work with and serve. We are accountable to the public and each other.

Tradition—We are proud of it; we learn from it; we are not bound by it. We use the best of our past to meet the challenges of the future. Employees have internalized the National Park Service mission and the traditions of the agency and it is evident in their work and interactions with one another and the public. This creates a continuum between the past, present and future that sustains a vital agency.

Respect—Inclusion, empathy and dignity form the basis for our actions. We embrace the ever-changing tapestry of our employees, visitors, sites and the stories they represent. In our interactions with each other, visitors and stakeholders we are understanding and respectful. We also encourage creativity and talents.

Shared Stewardship—We champion outstanding resource stewardship whenever and however it occurs. We are caretakers of the tangible and intangible resources and values of our American heritage. In doing this, we maintain a steadfast commitment to provide public awareness and appreciation of this nation's heritage. The National Park Service advances heritage preservation whenever and however possible. We recognize that we do not have all the answers to every challenge. The insights and knowledge obtained from others contribute to the preservation and interpretation of our shared heritage.

The Lake Roosevelt Floating Classroom program seeks to further these National Park Service core values. The purpose of the Floating Classroom program is to expose students and their communities in the upper Columbia River watershed to the significant scientific, social and economic factors that affect the lake's water quality and ecosystem. Inspiring students to give future thought to water quality at Lake Roosevelt is essential to preserving the precious resources of the upper Columbia River watershed.

History

Stretching for 150 miles from the Grand Coulee Dam to the U.S./Canadian border, Lake Roosevelt is the primary storage reservoir for the entire Columbia River System. The shear size of Lake Roosevelt's watershed contributes to complex environmental issues that can cross state, tribal and international boundaries. For example, area economies are largely resource-based, with significant logging, mining, farming and ranching along the length of the lake. The water quality of Lake Roosevelt has the potential to be adversely affected by this rural multiple-use economy as well as by the expansion of recreational activities on the lake. Recognizing the educational needs of area students, teachers and communities, Lake Roosevelt National Recreation Area was selected for a pilot watershed education project by the Washington State Governor's Council on Environmental Education in 1994.

As part of this watershed education project, the National Park Service developed the Floating Classroom program. In the spring of 1995, eight schools and 150 students and teachers within the Lake Roosevelt watershed participated in the pilot venture for this program. Each science class involved spent two days and one night aboard two laboratory-equipped houseboats. Time was spent on the lake conducting basic water quality sampling and chemical testing at two predetermined localities, discussing what the data indicated about the health of the lake and applying their knowledge to several true-to-life scenarios. Park rangers taught the students how to use the water sampling equipment and guided the students through the physical and chemical water quality tests. Through role playing, the students were challenged to apply their data while investigating and attempting to resolve complex watershed issues. The Floating Classroom not only provided experience in hands-on water quality monitoring, but also exposed students and teachers to past, current and future watershed problems. This basic template was deemed successful that the onboard program has remained fairly static since its inception.

In 1996, a five-day Floating Classroom curriculum was developed to provide students with a grounding in basic water quality, limnology and watershed dynamics before they set foot on the houseboats. A post-Floating Classroom community project was also added. After their floating classroom trip, each class was encouraged to share the information they learned from the Floating Classroom program with their immediate community through a newspaper article or presentation to the school board or community organization. The addition of the community project to the Floating Classroom program significantly widened the scope of the program audience from twenty high school science students to entire towns and communities. The program has continued to make new partners from that point. As of 2001, sixteen classes from twelve high schools now participate in the eight annual Floating Classroom trips.

Teachers have now been using the 1996 Floating Classroom curriculum for five years and have been tendering their comments for curriculum updates and improvements to the National Park Service staff. This document incorporates as many of their comments and improvements as possible and is the jumping-off point for the next five years of Floating Classroom trips. Just as the program has evolved to its current form over its first six years, as more students and teachers continue to participate, the evolution will continue. The Floating Classroom program remains a collaborative effort and the National Park Service continues to value teachers' opinions of this document

Students from Columbia High School perform chemical tests on Lake Roosevelt water samples with the assistance of a park ranger.

Participation Requirements

The Floating Classroom program is an intensive, field-based learning experience. It is not a vacation for students, teachers or park rangers. For the first six years of the program, schools and the National Park Service have experimented with what the requisite maturity level and academic preparedness of the participants should be. ***These experiments have proven that students that excel in and get the most out of the Floating Classroom program have completed either a year of biology or chemistry before embarking on a trip.*** This prerequisite means that the students will have a firm grounding in *at least* one of these sciences before the trip. This academic requirement should limit the Floating Classroom program to ***high school juniors and seniors*** for whom this curriculum and the Floating Classroom program are designed.

Before embarking on a Floating Classroom trip, liability and behavioral agreements must be met. These participation agreements, one to be signed by the school principal or school district superintendent and the other to be signed by each participating student and that student's parent or legal guardian, may be found in Appendix A. All liability paperwork must be completed before the boats leave the dock on a Floating Classroom trip.

The school principal or school district superintendent should understand the following terms as they are set forth by the houseboat rental company (Roosevelt Recreational Enterprises) and the National Park Service. The participating school must:

1. have adequate liability insurance for an overnight houseboat excursion on Lake Roosevelt, including coverage for damage or injury to participating students and school staff or property suffered on, in or about the houseboats by reason of the school's participation in the Floating Classroom program.

Winter decends upon Lake Roosevelt and the Colville River.

2. provide transportation for students and school staff to and from the designated departure and arrival marina site or make similar or acceptable arrangements.

3. pay for all gasoline and oil used by the houseboats upon receipt of the invoice from Roosevelt Recreational Enterprises. Each school will present a purchase order to Roosevelt Recreational Enterprises in advance of the trip for issuance of an invoice.

4. plan, purchase, pack, prepare and clean up after their own group meals, to include lunch and dinner on the first day and breakfast and lunch on the second day. The houseboats are equipped by Roosevelt Recreational Enterprises with cooking and eating utensils.

5. leave the houseboats as clean as when they were boarded. Cleaning supplies and equipment are provided.

6. provide at least two adults (a teacher and an opposite sex chaperone) to accompany and supervise the participating students and provide for any necessary substitute teachers during the absence of the participating teacher(s).

7. obtain signed parental permission forms for all participating students, including any necessary permission for absence from classes and arrangements for assignments.

8. review the Floating Classroom safety and behavior guidelines with all participating students, and obtain student and parental signatures on guideline forms.

9. agree that the National Park Service and Roosevelt Recreational Enterprises are not responsible for any property left stored, lost or transported by students or school staff in, on or upon houseboats before, during or after the Floating Classroom program.

10. understand that the National Park Service assumes responsibility for the operation of the houseboats and accordingly, the United States of America will be liable for the negligent conduct of its employees acting within the scope of their employment to the extent, and as allowed by, the Federal Tort Claims Act, 28 USC 2674 et seq.

Student participants are subject to the rules and regulations of the Floating Classroom program. Though the Floating Classroom is program is supposed to be fun, it is school, nonetheless. There will be ample free time, however this is a working trip with specific scientific and educational objectives. Before embarking on a Floating Classroom trip, student participants and

Two Floating Classroom Houseboats moored in a cove in the Nine Mile area of Lake Roosevelt on the Colville Indian Reservation.

their parents must agree to the following conditions:

1. The student will notify both the teacher and the National Park Service staff of any preexisting medical conditions or medications that are taken on this field trip.

2. The student will understand that the two boats are to be divided into girls and boys sleeping quarters. There will be no crossing from boat to boat after 10:00PM. If weather permits, students may sleep on the top deck of the houseboats. No one will be allowed to sleep on shore or any other place other than their designated houseboat. Quiet hours are from 10:00PM to 6:00AM.

3. All students will participate in meal preparation and/or cleanup, and the final boat cleanup at the end of the trip.

4. The student will come prepared for all types of weather conditions. It is strongly recommended that students bring sleeping bags and layered clothing. Keep in mind that there is little space on the houseboats, so there should be no more than one extra set of clothes per trip. All accessories should be kept at home.

5. Televisions, radios, tape players, CD players or other music players are not allowed on board.

6. Horseplay or other disruptive behavior will not be tolerated.

7. The use of tobacco products, alcohol or drugs is **strictly prohibited**.

8. Instructions or directions of National Park Service staff must be followed.

9. If any of the above guidelines are abused or broken, it may result in the immediate cancellation of the trip and the immediate return to the marina for the entire group.

These regulations are enacted for the safety and enjoyment of all participants, teachers and National Park Service staff members. Agreement upon these conditions by the school, the students, the teachers, Roosevelt Recreational Enterprises and the National Park Service is a condition of participation. Again, copies of these documents are available for photocopying in Appendix A.

Goals, Objectives and Essential Academic Learning Requirements

In 1987, the Washington State Legislature mandated that science with special reference to the environment be included in the basic instruction given in all common schools. In response, the State Board of Education passed the following rule, WAC Chapter 180-50-115(6), in 1988: "Pursuant to RCW 28A.230.020 instruction about conservation, natural resources, and the environment shall be provided at all grade levels in an interdisciplinary manner through science, the social studies, the humanities, and other appropriate areas with an emphasis on solving the problems of human adaptation to the environment." The Floating Classroom program was developed to meet and exceed this educational statute.

Floating Classroom Goals

The Floating Classroom program, through implementation of the curriculum by teachers in the classroom, practical instruction aboard the laboratory-equipped houseboats by park rangers and the completion of the community outreach project after the trip, strives to meet the following goals. The Floating Classroom program will:

1. improve student skills in biology and chemistry.
2. create a more thorough student and community awareness of environmental issues affecting the Lake Roosevelt watershed.
3. provide students with the academic and problem-solving skills necessary to mediate conflicting and competing watershed usage issues.
4. promote effective student participation in community affairs.

Floating Classroom Objectives

After completing the Floating Classroom curriculum in the classroom, the practical instruction aboard the laboratory-equipped houseboats and the completion of the post-trip community outreach project, the student participants will be able to:

1. describe the complex relationships of a watershed including the hydrologic cycle, natural and human determinants, basic limnology, and the food chain of Lake Roosevelt.
2. explain the physical and chemical properties that determine water quality and the reasons why certain water quality tests are important.
3. describe how geology, precipitation, and land use affect the upper Lake Roosevelt watershed and influence the water quality of Lake Roosevelt.
4. apply 10 physical and chemical water quality tests to Lake Roosevelt water samples.
5. discuss the ecological, political, social and economic factors influencing Lake Roosevelt's water quality.
6. explain how each specific water quality test is used to measure water quality.
7. describe the importance of accurate, unbiased data collection.
8. describe the limits and possible errors that can affect each water quality test.
9. describe the two types of plankton that exist in the Lake Roosevelt ecosystem and articulate the differences between the two.
10. discuss how the creation of Lake Roosevelt by the Grand Coulee Dam changed the ecosystem of the Columbia River.
11. apply basic mathematical, chemical, physical, biological and behavioral science knowledge to discern past, current and future water quality patterns for Lake Roosevelt.
12. list the dominant users and managers of the Lake Roosevelt watershed and their possible positive and negative impacts upon Lake Roosevelt's water quality.
13. discuss the conflicting interests between these dominant users and managers of the Lake Roosevelt watershed and devise possible compromise solutions.
14. share the knowledge gained from the Floating Classroom program with the local community.

Essential Academic Learning Requirements

Developed by the Washington State Commission on Student Learning, the Essential Academic Learning Requirements (EALRs) are a core of common subjects and skills that all students in Washington are expected to master. The Education Reform Act of 1993 mandates that the EALRs should be fully implemented in schools by the 2000-2001 school year. It is the goal of the National Park Service to tailor the Floating Classroom curriculum, trip and community project to the EALRs so that this program is more than just a classroom supplement. Currently, the program primarily addresses the following benchmarks in science, geography and communication. Though these benchmarks are specifically for 10th grade students, the Floating Classroom program is designed for 11th and 12th grade students.

Science

1. Understand and apply scientific concepts

"...instruction about conservation, natural resources, and the environment shall be provided at all grade levels in an interdisciplinary manner though science, the social studies, the humanities, and other appropriate areas with an emphasis on solving the problems of human adaptation to the environment.

and principles.

- A. Identify, describe and categorize living things based upon their characteristics.
- B. Measure properties and characteristics.
- C. Recognize the components, structure and organization of systems and the interconnections within and among them.

2. The student conducts scientific investigations to expand understanding of the natural world.
   - A. Think logically, analytically and creatively.
   - B. Understand the relationship between evidence and scientific explanation.

3. The student applies science knowledge and skills to solve problems or meet challenges.
   - A. Identify problems and challenges in which science knowledge and skills can be applied.
   - B. Research, design and test a variety of ways to address problems and/or challenges.
   - C. Evaluate solutions and consequences.

4. The student uses effective communication skills and tools to build and demonstrate an understanding of science.
   - A. Use listening, observing and reading skills to obtain science information.
   - B. Use writing and speaking skills to organize and express science ideas.
   - C. Use effective communication strategies and tools to prepare and present science information.

5. The student understands how science knowledge and skills are connected to other subject areas and real-life situations.
   - A. Understand the relationship between science and technology.
   - B. Examine the relationship between science and history.
   - C. Examine the relationships among science, society and the workplace.

Geography

6. The student understands the complex physical and human characteristics of places and regions.
   - A. Describe the natural characteristics of places and regions and explain the causes of their characteristics.
   - B. Describe the patterns that humans make on places and regions.

7. The student observes and analyzes the interaction between people, the environment and culture.
   - A. Identify and examine people's interaction with and impact on the environment.
   - B. Analyze how the environment and environmental changes affect people.

Communication

8. The student uses listening and observation skills to gain understanding.
   - A. Focus attention.
   - B. Listen and observe to gain and interpret information.
   - C. Check for understanding by asking questions and paraphrasing.

9. The student uses communication strategies and skills to work effectively with others.
   - A. Use language to interact effectively and responsibly with others.
   - B. Work cooperatively as a member of a group.
   - C. Seek agreement and solutions through discussion.

Floating Classroom students from Mary Walker High School pose for a class photo before a morning hike.

Lesson 1

Watersheds and the Water Cycle

Objectives
The student will understand the components of the water cycle and become familiar with the physical and human geography of the Columbia River and Lake Roosevelt watersheds. With this knowledge, students will work cooperatively to construct their own complex watershed.

Vocabulary
Water cycle (or hydrologic cycle)
Solar energy
Evaporation
Transpiration
Precipitation
Infiltration
Permeability
Aquifer
Water table
Watershed
Topographic map

Supplies
—Copies of topographic maps that include your town or surrounding area
—Enlarged photocopies or transparencies of Lesson 1 visual aids in Appendix B
—A sandbox, playground or similar sandy area that can be manipulated into a watershed model
—A garden hose and water supply

Methods
The teacher introduces the students to the water cycle. Visual aids are provided in Appendix B.

The teacher introduces the students to the physical and human geography of the Columbia River watershed in a classroom discussion or reading assignment. Visual aids are provided in Appendix B.

The students construct and test their own watershed outside.

Lesson 1
Watersheds and the Water Cycle

The Water Cycle
In order for scientific investigators to understand the biology and chemistry that affect rivers, lakes and other bodies of water, they must first understand the bigger picture of how water travels over and through a landscape. Bodies of water are affected by numerous atmospheric and environmental factors that can impact the biology, chemistry, abundance and distribution of water. These collective factors are known as the **water** (or **hydrologic**) **cycle**.

There are more than one trillion gallons of solid, liquid and gaseous water on earth. Of that trillion gallons, at any one time, a staggering 97.2% is found in oceans. Another 0.008%can be found in inland seas and salt lakes. Thus, more than 97% of all of the earth's water is salty and not readily drinkable. Ice caps and glaciers subsume more than 2% of the earth's water. Groundwater, freshwater lakes and rivers, and gaseous water in the atmosphere comprise less than 1% of the earth's water (Table 1-A, Appendix B). If all of the liquid water on earth were poured on top of the United States, it would cover the land to a depth of 90 miles!

The water cycle is the endless circulation of water through the environment (Figures 1-B and 1-C, Appendix B). The cycle begins when **solar energy** (energy from the sun) excites water molecules. Depending upon the location of those excited water molecules, one of two things can occur. If the excited molecules are at the surface of a body of water, the molecules will **evaporate** into the atmosphere as the liquid transforms into a gas. Evaporation may occur in a body of water as large as a lake or ocean or as small as a puddle or droplet of sweat on the forehead of an athlete. If the excited molecules are held within the tissues of plants, **transpiration** occurs. Transpiration describes the evaporation of water from pores in the leaves of plants.

In its gaseous form, water accumulates into clouds. **Precipitation** occurs when water vapor accumulates around a small particle and falls to the earth as a either a solid or liquid (depending upon temperature). Upon returning to earth, water may follow one of many paths. It may evaporate once again and return to the atmosphere, it may collect in streams, rivers, ponds or lakes, it may flow across the land as runoff into a larger body of water like a lake or river, it may be consumed by living organisms like animals and plants or it may be soaked into the soil in a process called **infiltration**. Regardless of the course the precipitated water takes, it will eventually evaporate or transpire back into the atmosphere.

Permeability is the ability of water to infiltrate into the soil. Permeability is dependent upon the physical composition of the soil. Soil composed of larger particles such as sand or gravel is more permeable than soil composed of small particles such as silt or clay. Thus silty or clayey soils absorb less water and causes more runoff than sandy soil. Water that is able to infiltrate into the soil becomes part of a groundwater system that is held in an **aquifer**, which is a porous layer of rock or sediment that can retain water. The top layer of an aquifer is called the **water table**. Aquifers are usually deep within the earth but they are sometimes found close to the surface. When an aquifer reaches the surface, water is expelled in the form of a spring.

One of the most important functions of the water cycle is that it works as a highly efficient water filter. Chemicals or other compounds that dissolve in water can be difficult to 'un-dissolve.' The water cycle quite elegantly and naturally removes impurities from water via evaporation and infiltration. When water evaporates, the bonds holding liquid water together are broken as water reverts to its molecular (gaseous) state. Dissolved chemical impurities are held in water by similar bonds. Evaporation breaks these bonds and the chemicals are released. Evaporation will also filter larger, heavier particles from water. Water percolating through the soil cannot carry large particles as it travels. Thus, infiltration has a similar effect.

Once water reaches the surface of the earth and is either consumed by plants or animals or becomes incorporated into a larger body of water such as a lake, ocean, river or stream, the water cycle can begin again. So long as there is surface water and solar energy, there is the raw material for the continuance of the water cycle.

The Columbia River and its Watershed

Whenever it precipitates from the atmosphere, some water permeates the ground and enters the aquifer and some water flows downhill over the land as runoff. This water collects in channels such as rivers or streams and continues moving from a high point to a low point. Eventually, water from streams and rivers will collect in larger bodies of water such as ponds, lakes or oceans.

A **watershed** is an area whose runoff feeds a particular stream. Watersheds are separated by areas of higher elevation than the stream channel called ridgelines or divides. They may be as small as a single mountain valley or as large as an entire drainage basin or even a continent. Near a divide, stream channels are narrow and contain fast moving water. As stream channels move further from a divide, the slope of the land decreases and the velocity of the water diminishes until the stream enters into a larger body of water.

The Columbia River watershed drains a 259,000-square-mile basin that includes territory in seven states (Oregon, Washington, Idaho, Montana, Nevada, Wyoming, and Utah) and one Canadian province (British Columbia) (Figure 1-D, Appendix B). The Columbia River flows for more than 1,200 miles, from the base of the Canadian Rockies in southeastern British Columbia to the Pacific Ocean on the border of Washington and Oregon. Although humans have lived along the river for more than 10,000 years, modern engineering has dramatically altered the character of the Columbia. Some scientists believe that today the river is environmentally threatened and that drastic action should be taken to reverse the changes made during the last 150 years.

The Columbia originates in two lakes that lie between the Continental Divide and Selkirk mountain ranges in British Columbia, Canada. It flows north for its first 200 miles, then it turns south and runs to the international border. Within the United States, the river courses southwest and skirts the Columbia Plateau's massive lava flows, then it turns to the southeast, cutting a deep gorge in the volcanic sediments to its junction with the westward flowing Snake River. From its confluence with the Snake, the Columbia runs nearly due west to the Pacific Ocean. Fifteen percent of the basin—more than 39,000 square miles—lies in Canada. The largest of the river's major tributaries is the Snake River, itself more than 1,100 miles long. The Columbia River Basin includes a diverse ecology that ranges from temperate rain forests to semi-arid plateaus, with precipitation levels that range from 110 inches to 6 inches per year.

Importantly, the Columbia is a snow-charged river that seasonally fluctuates in volume. Its annual average discharge is 160 million acre-feet of water, with the maximum volumes between April and September, and minimum volumes from December to February. From its source at 2,650 feet above sea level, the river drops an average of more than 2 feet per mile, but in some sections it falls nearly 5 feet per mile.

The Columbia River Basin is the most dammed river system in the world. More than 400 dams—11 of which are on the main stem of the Columbia—and hundreds of structures on tributaries block river flows and tap a large portion of the Columbia's electrical generating capacity: more than 21 million kilowatts. The dams create large reservoirs that provide flood control and water for a vast irrigation projects on the Columbia Plateau. A treaty with Canada in 1964 clarified the amount of water storage and hydropower each country would receive from the river.

Overuse of the waters of the the Columbia has contributed significantly to steep declines and even extinctions of some historically strong anadromous fish runs. Between the 1860s and 1960s, commercial fisheries annually harvested millions of pounds of fish, particularly salmon. Since the early 1970s, the fish catch has dramatically declined, with hatchery-raised species making up more than 80 percent of commercially caught salmon in the Pacific Northwest. Fish hatcheries began operation in the Columbia Basin in the late 19^{th} century and became a major response to salmon declines during the late 20th century. In 1992, the government listed the native Snake River Sockeye salmon as endangered under the Endangered Species Act, and in 1998 Willamette steelhead joined the list of endangered fish.

As early as the 1870s, Columbia River water was used to irrigate agricultural land. During the 1930s and 1940s, however, the construction of the big dams, especially Grand Coulee Dam on the upper river and McNary Dam on the middle river, greatly increased irrigated agriculture on the Columbia Plateau. In 1948, the Columbia Basin Project began transporting Columbia River water by canal to more than 600,000 acres on farms in central Washington. Irrigated crops include alfalfa, potatoes, mint, beets, beans, orchard fruit and grapes, many of which are exported from Washington for profit.

Recreation on the Columbia was as popular in the past as it is today. In the late 19^{th} century steamboat excursions from Portland to the western end of the Columbia River Gorge were popular. Sport fishing, sailing, power boating, swimming, water skiing, canoeing, and other water sports have become commonplace on the river since World War II. Conservationists, including many hikers and outdoor enthusiasts, campaigned to preserve some of the scenic wonders of the Columbia River. Today, the Columbia River Gorge National Scenic Area, the Hanford Reach National Monument and Lake Roosevelt National Recreation Area provide recreational opportunities for visitors the world over.

Dams, fishing, recreation, human settlement, timber extraction, mining and industry have all had positive and negative effects on the Columbia River system, its environment and its people. These effects will continue to impact this area and it is the job of scientists, concerned citizens and Floating Classroom students to monitor the changes brought about by these factors.

Group Activity: Constructing a Watershed and Observing the Water Cycle

Divide the class into groups of 3-4 students and give each group a **topographic map** of your local area. A topographic map is a map that uses contour lines to show land elevation. Topographic maps can display towns, forests, roads, railroads, land ownership, and watercourses. Try to make sure that each map contains at least one watershed. If your students have never used a topographic map before, it may be necessary to provide a brief explanation on how to interpret a topographic map.

Have each group take a few minutes to study their map. Then, have each group make a list of the landforms and human developments on their map. Finally, have each group count the number of separate watersheds that are represented on their map. Make certain that they realize that all of the watersheds on their map probably make up a portion of an even larger watershed.

After studying the topographic maps, provide each group with a copy of Figure 1-D (Appendix B). This is a generalized drawing of the Lake Roosevelt watershed. Give the students two or three minutes to count the number of watersheds in this drawing.

Now provide each group with a copy of Figure 1-E (Appendix B). This figure is a photograph of a river system on the Arabian Peninsula in the country of Yemen. Each tiny finger of this river system is a separate watershed. Give the students 5 minutes to attempt to count the number of watersheds in the picture. There are actually over 1000 separate watersheds in this photo. Ask the students why they think this river system in Yemen is so branched while the Columbia River system is less branched?

Finally, take the students outside to a sandy area such as a playground. If a sandy area is not available, the activity can be done on a smaller scale inside with a bag of playground sand and a medium sized aquarium. Mark out some boundaries (a five-foot by five-foot square should suffice) and have the students construct their own watershed model out of sand and dirt using their hands or small trowels. Their construction should keep in mind that water must flow from high point to low point, that watersheds should be separated by divides and that tributary streams flow into larger rivers and ultimately into large bodies of water like lakes or oceans.

Once the watershed model has been completed, use a garden hose to add water to the watershed (make sure to use a head on the hose that diffuses water to simulate rain). The simulated precipitation should hit the divides between tributary watersheds first. Some will evaporate (invisible to the students) some will infiltrate into the soil and some will runoff into the tributary stream. Continue watering the tributaries until they are all flowing. The flow should continue down to a larger river, lake or ocean. If all of the water does not continue down to a larger collection area, then a closed basin has been created (a closed basin is a basin without an outlet to the sea—the Great Basin is an example). Have the students compare their watershed to the Columbia River watershed and the Yemen watershed. How are they similar/different?

Lesson Comprehension Questions

1. Describe, in general, the components of the water cycle.

2. What is a watershed? What watershed do you live in? What watershed does that empty into?

3. How does the water cycle relate to a watershed?

Lesson 2

Lake Water Chemistry

Objectives
The student will understand what the 10 common water quality tests are measuring and what these tests indicate about lake health. The students will perform these tests on the Floating Classroom trip.

Vocabulary
Van Dorn horizontal sampler
Thermal pollution
Dissolved oxygen
Percent oxygen saturation
pH
Total alkalinity
Turbidity
Secchi disk
Conductivity
Orthophosphate
Ammonia nitrogen
Nitrates
Nitrites

Supplies
None required. However, if the classroom is equipped with any of the kits required for the tests described below, performing these tests would be excellent preparation for the trip and would give students a comparative baseline for the data collected on the Floating Classroom trip.

Methods
The teacher may use the information in this packet as they see fit. They may present this information as a lecture or provide it to the students as a reading assignment. If available, the teacher may also augment this lesson with chemical tests in a laboratory setting.

Lesson 2
Lake Water Chemistry

How do we know if water we drink is safe? What kinds of chemicals are found in the water we swim in? How do we know if a watershed is as healthy today as it was 10 years ago? How can we make sure that our lakes, streams and reservoirs stay clean so that all plants, animals and people in the watershed can continue to use them? These are just a small sampling of the questions that can be answered through water quality sampling and testing.

Everything that humans and animals do affects our water, either positively or negatively. However, before we can identify the harm or help that human actions are causing, we must be able to demonstrate that a body of water is indeed impacted by a certain human activity. If a negative impact is detected, we must assess the degree of the damage, determine who or what is responsible and prepare a plan to repair that damage. These actions hinge upon the collection of accurate water quality data. If tests demonstrate that a lake is healthy, then it becomes the duty of scientists, concerned citizens and Floating Classroom students to insure that the watershed remains healthy. If the chemical tests expose a concern about the water quality of a lake or river, it falls to scientists, concerned citizens and Floating Classroom students to develop a hypothesis as to what has caused the problem and how that cause can be minimized or eliminated.

The following lesson will introduce Floating Classroom students to the water quality tests that will be performed on board, how these tests work, why they are performed and what they are designed to reveal about water quality. This material is designed only as an introduction; more detailed instructions and explanations will be provided before, during and after the on-board testing.

Water Sampling
Before any samples are collected, it is vital to record the many variables that can influence test results. Among these variables are the current weather conditions, time of year, time of day, and water elevation. It is extremely important to be careful and consistent in the methodology used to collect samples. It is also very important to remember that no one sample can represent the entire lake. Each test is just a snapshot of the water quality at that time. Thus, the most accurate data is an accumulation of many samples from a variety of locations, depths and times. One of the objectives of the Floating Classroom program is to build up a large database of water quality 'snapshots' so that trends can be observed and understood.

The water sampler used on the Floating Classroom is called a **Van Dorn horizontal sampler**. The sampler is a clear, plastic tube on a length of rope that can be opened and closed at both ends. The ends are propped open like a mousetrap while the sampler is lowered to the desired depth. The line used to lower the sampler is marked in 1-meter sections and is equipped with a weight called a messenger. When the sampler reaches the desired depth, the messenger is released and when the messenger hits the sampler, the trap is sprung, the ends close, and the sampler can then be lifted to the surface with the sample water trapped within the tube.

Temperature and Temperature-Sensitive Tests
Water temperature has a major influence on biological activity and growth. Temperature also has a direct effect upon many of the biological and chemical characteristics of a body of water. The rate of chemical reactions generally increases at higher temperatures, which can in turn increase biological activity like respiration and photosynthesis. Warmer water also increases the sensitivity of some organisms to pollution, parasites and diseases. Temperature changes will also affect the pH and dissolved oxygen levels in a body of water.

Typically, the temperature of a body of water will change slower than the temperature of the air and land surrounding it. Thus, lake temperatures do not fluctuate daily the way air temperatures do. Water temperatures may artificially rise due to a number of factors which can collectively be called **thermal pollution**.

Two students collect a water sample with a Van Dorn horizontal sampler. The water will be used for Floating Classroom chemical tests.

Thermal pollution is the expulsion of warm or hot water into an natural body of water causing the temperature of the natural body of water to rise. Thermal pollution can result from industrial areas where water is used to cool machinery or make steam for power. It can even result from storm water running off warm streets, sidewalks and parking lots and into a lake. People can also impact water temperature by cutting down trees that shade a body of water. The resulting soil erosion will increase the temperature of water as well, since cloudy water absorbs more heat than clear water.

Oxygen dissolved in water is essential for the maintenance of healthy lakes and rivers. Scientists will often refer to water's **dissolved oxygen** (or D.O.)content which, not surprisingly, is the amount of oxygen dissolved in water, typically measured in milligrams per liter. The presence of oxygen in water is a positive sign while the absence of oxygen often signals severe pollution. Most aquatic animals need oxygen to survive. Fish and some aquatic insects have gills to extract oxygen from the water. Different organisms, however, have different oxygen requirements. Trout, for example, need high levels of dissolved oxygen to survive while carp and catfish can survive with lower levels of dissolved oxygen. Different kinds of macroinvertebrates also have variable oxygen requirements.

Much of the dissolved oxygen in water comes from the atmosphere. Waves on lakes act to mix atmospheric oxygen into the water. Waterfalls, dam spillways and penstocks, and boat propellers will also churn up water and increase the dissolved oxygen level of a body of water. Algae and aquatic plants produce oxygen as a byproduct of photosynthesis. The more plant life in a lake, the greater the daily fluctuation in dissolved oxygen. This is because dissolved oxygen levels will rise during daylight hours when photosynthesis is occurring and oxygen is being produced. At night, the photosynthesis process stops and the respiration process begins. Plants then take in dissolved oxygen from the water. Thus, during the night, dissolved oxygen levels will decrease.

Water temperature directly affects dissolved oxygen levels; oxygen is more soluble in cold water than in warm water. Hence, dissolved oxygen readings will likely be higher in the winter and spring when water temperatures are lower. Human activities may cause changes in an aquatic ecosystem which may in turn cause changes in dissolved oxygen concentrations. Runoff from areas with a build-up of organic wastes such as animal feces, failing to collect and compost or properly dispose of leaves that end up in steams or lakes, and runoff or groundwater leaching from urban and agricultural fertilizer application may stimulate algae and aquatic plant growth. As these plants die, they fall to the lake bottom to decompose. Bacterial breakdown of the organic matter uses dissolved oxygen. The more organic matter there is to decompose, the more oxygen is required and the chances of oxygen depletion increase.

Overall, dissolved oxygen content is one of the most important water quality indicators. If dissolved oxygen levels are consistently high, the water system is usually healthy. From the dissolved oxygen content of water, scientists will also calculate the **percent oxygen**

saturation in water. Percent oxygen saturation is the percent of milligrams of oxygen gas dissolved in one liter of water at a given temperature compared with the maximum milligrams of oxygen gas that can dissolve in one liter of water at that same temperature. Percent saturation is calculated using a graph that relates temperature to dissolved oxygen content. Thus, as temperature changes, the dissolved oxygen content and the percent saturation will change with it. For this reason, it is extremely important to test for temperature and dissolved oxygen immediately after removing a sample from a body of water as the temperature may fluctuate and skew the test results.

A water molecule is composed of a hydrogen ion (H^+) and a hydroxyl ion (OH^-). The **pH** is the concentration of unbonded hydrogen ions in a liquid. Every liquid has a pH value ranging from 1 to 14. Pure, deionized water has a pH of 7 (neutral). If a sample has more hydrogen ions than hydroxyl ions, it is acidic and has a pH less than 7. If a sample contains more hydroxyl ions than hydrogen ions, it is basic and has a pH greater than 7. Maintaining a balanced, healthy pH is extremely important to plant and animal life in a body of water. Most organisms have an ideal pH range in which they can live; an environment that is too acidic or basic will lead to that organism's death.

The pH scale is a logarithmic scale meaning that each one-unit change on the pH scale indicates a ten-fold change in the acidity or alkalinity of the sample. Thus, water with a pH of 5 is ten times more acidic than water with a pH of 6. Battery acid, lemon juice and cola are all acidic while ammonia, bleach, and Drain-o are all basic. Most lake and water bodies are slightly basic because they contain alkaline-based sediments. Rain water is usually acidic, ranging between 5.5 and 6.5, because natural and human caused nitrogen oxides and sulfur dioxides convert to nitric and sulfuric acids in the atmosphere. These trace acids then combine with moisture in the atmosphere and fall to earth. Like dissolved oxygen, pH is dependent upon temperature and should be tested for immediately after collecting a sample from a body of water.

Non-Temperature Sensitive Tests

The **total alkalinity** of a fluid describes a fluid's ability to resist changes in pH that could result from the addition of an acid or base. Thus, total alkalinity measures the buffering capacity of a fluid. Buffers minimize changes in the concentrations of hydrogen and hydroxyl ions. Most buffers are weak acids or weak bases that combine reversibly with hydrogen or hydroxyl ions to achieve a pH equilibrium.

Turbidity is the measure of how much material or how many particles are suspended in water. Turbid water is cloudy while non-turbid water is very clear, though even the clearest lakes have some suspended particles. These particles can include soil and silt, sewage, industrial waste, and microorganisms.

A number of factors can increase the level of water turbidity. Erosion by wind, water and ice may all increase solids in a river or lake. Increases in the populations of microorganisms can also increase turbidity. An influx of fertilizers may, in itself, increase turbidity or lead to an increase in microorganisms that will also increase turbidity. Human activities such as dumping garbage and sewage as well as boat traffic will also have an effect.

Turbidity is measured using a **Secchi disk**. A Secchi disk is a black and white plate on a rope. The disk is lowered into the water until it is no longer visible and the depth is recorded. Thus, when using the Secchi disk, depth is measured in meters as a unit of visibility.

Conductivity is a convenient method of estimating the amount of dissolved ions or other solids that conduct electricity in a water sample. Pure, distilled water will not conduct any electricity. The ability of water to conduct electricity hinges upon the presence

of ions and other particles. Samples with high conductivity readings usually contain dissolved ions such as chlorides, nitrates, orthophosphates, sodium, calcium, magnesium, iron and aluminum. Uncharged soluble organic materials such as oils, phenols, alcohol and sugar, can not carry a current and so are not measured by the conductivity meter.

Conductivity is usually related to the chemical purity of water, the amount of dissolved ions in a solution, and salt concentrations. For example, a relatively pure river will have a conductivity reading of around 100-200 $\mu S\ cm^{-1}$. A river or lake with a great deal of suspended solids (sediments, algae, zooplankton, and other organic material in water) may have a conductivity reading more than 1,000 $\mu S\ cm^{-1}$. For example, Lake Roosevelt typically has a conductivity reading of 150-200 $\mu S\ cm^{-1}$ while the Mississippi River or Colorado Rivers typically have a conductivity of 1500-3000 $\mu S\ cm^{-1}$.

Phosphorus is found naturally in aquatic systems; however, most is bound in particulate matter (algae, bacteria, and rock fragments). Phosphorus is often the least abundant element of the major nutrients required for plant metabolism and thus is typically the limiting factor in plant and algal growth.

The most important form of phosphorus for plant nutrition is ionized inorganic phosphate (PO_4^{-3}), also called **orthophosphate.** When algal cells die and decompose most of the phosphorus released is organic and must undergo bacterial degradation before being used by algae. When larger aquatic plants die they rapidly release phosphorus which is then utilized by bacteria and algae.

Inorganic phosphates from human activities such as sewage spills, industrial wastes, soil erosion, fertilizers, and, in the past, laundry detergents, contribute additional phosphorus into lakes and rivers. The introduction of excessive phosphates to the aquatic system will interrupt the balance of the natural concentration of nutrients causing an overabundance of algae and aquatic plants called an algal bloom. As phosphates are artificially introduced into an aquatic ecosystem such as a lake, rooted aquatic plants become more abundant. These plants, in turn, take up phosphorus from the bottom sediments and release it into the water during active growth and when they die theydecompose. Eventually, lakes may fill with aquatic vegetation making swimming, boating and fishing less desirable. This massive growth of plants often causes lakes to become oxygen deficient.

Since plants and algae are so dependent upon phosphorus and incorporate it immediately into their tissues, the presence of phosphorus in a body of water in anything but trace levels is cause for concern. If there is too much phosphate in a body of water for all of the plants and algae in that body of water to incorporate into their tissues immediately, then a massive influx of phosphate has occurred. Forest fires and volcanic eruptions, both with the help of soil erosion, can naturally raise the phosphate level in a body of water while sewage spills and fertilizer runoff can unnaturally increase phosphate levels. Like water, phosphorus cycles through the ecosystem in a semi-predictable manner (Figure 2-A, Appendix B)

Nitrogen gas (N_2) is the most abundant gas in the Earth's atmosphere (79%). However, this type of nitrogen is useless to plants. Only certain bacteria have the ability to utilize atmospheric nitrogen. These bacteria produce ammonia (NH_3) which can be utilized by most plants. **Ammonia**, in turn, is also assimilated by other bacteria (called nitrifying bacteria) that produce **nitrates** (NO_2^-) and **nitrites** (NO_3^-) which can also be used by plants. Ammonia is the form of nitrogen most readily utilized by algae and aquatic plants, however, most ammonia is first metabolized by nitrifying bacteria which then excrete nitrate or nitrite. Nitrate and nitrite are then metabolized by plants and algae, but the nitrate/nitrite metabolism is much slower when compared to the metabolization of ammonia. Like water and phosphorus, nitrogen cycles through the ecosystem in a semi-predictable manner (Figure 2-B, Appendix B).

Nitrogen is an essential nutrient used by organisms to make proteins. Primary producers absorb nitrogen directly from the water or, in the case of some aquatic plants, absorb it through their roots. Natural inputs of nitrogen into an aquatic system include: nitrogen-fixing bacteria, aquatic organism excretion (animals), decomposition of organic matter, precipitation (nitrates in rainfall), erosion and groundwater. Human activity such as sewage leaks, runoff from residential and agricultural fertilizers, runoff from cattle grazing areas or feedlots and the improper disposal of plant debris (i.e. leaves and grass clippings from yards that are allowed to be washed into streams via storm drains) will also increase the nitrogen level in a body of water.

Lesson Comprehension Questions:

1. How does temperature affect the biological activity of a lake or river?

2. How does temperature relate to the dissolved oxygen content of a lake or river?

3. What does pH measure? Is rainwater basic, acidic or neutral? Why?

4. What are some of the causes of increased turbidity in a body of water? What device is used to measure turbidity?

5. Does pure, deionized water conduct electricity? Why?

6. What are two chemical nutrients that plants and algae require to grow and metabolize?

7. What are the three forms of nitrogen that plants can metabolize? Which form is most easily metabolized?

Lesson 3

Lake Biology and Ecology

Objectives

The student will understand the how biologists characterize lakes, how the chemical tests explained in Lesson 2 relate to the health of a lake ecosystem, and how a lake ecosystem operates. The students will apply this information to Lake Roosevelt on the Floating Classroom trip.

Vocabulary

Ecology
Organismal ecology
Population ecology
Community ecology
Ecosystem ecology
Plankton
Phytoplankton (algae)
Zooplankton (protozoa)
Life history
Food chain
Primary producers
Primary consumers
Secondary consumers
Tertiary consumers
Decomposers
Eutrophic
Mesotrophic
Oligotrophic

Supplies

None required.

Methods

The teacher may use the information in this packet as they see fit. They may present this information as a lecture or provide it to the students as a reading assignment. If available, the teacher may also augment this lesson with microscope exercises in a laboratory environment.

Lesson 3
Lake Biology and Ecology

Ecology is the study of the interactions between organisms and their environment. Most organisms require a certain set of environmental conditions to survive. However, the very presence of some organisms in an environment can change the character of that environment. Thus, the relationship is two-fold; the environment affects the organisms that live in it but organisms have just as much influence over changes in their own environment.

Ecology can be discussed on four different levels. **Organismal ecology** is concerned with the behavioral, physiological and morphological ways in which individual organisms meet the challenges posed by their environments. **Population ecology** concentrates primarily upon environmental factors that affect groups of organisms of the same species in a particular geographic area. **Community ecology** studies the interactions (predation, prey, competition) that exist between all of the organisms that inhabit a particular environment. While community ecology subsumes all life within an area, **ecosystem ecology** studies all living things and their interactions with each other and the non-living things in their environment. It should now be very evident that the science of ecology is extremely complex.

Freshwater ecosystems include not only the body of water itself, but the community of plants and animals that live around and utilize that body of water. Thus, the health of a freshwater ecosystem is strongly dependent upon interactions between the aquatic and terrestrial communities. It is important to understand all of the interactions that affect an ecosystem and to not overlook those interactions that may originate from outside a perceived system.

Organismal Ecology

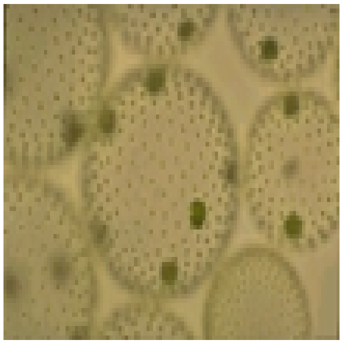
Lakes are home to a wide variety of organisms, both large and microscopic. Fish, plants and plankton are the primary organisms that live within lakes while insects, reptiles, amphibians, birds and mammals will use a lake as part of their larger habitat. Of particular importance to the ecological health of a lake are **plankton** which will be discussed in more depth. Plankton are the microscopic organisms that drift passively or swim weakly near the surface of lakes or other large bodies of water.

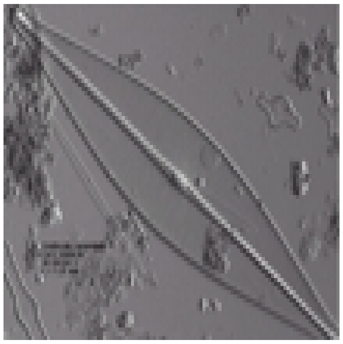
Plankton come in an amazing diversity of forms. In general, they can be divided into two categories: phytoplankton and zooplankton. **Phytoplankton** are plant-like plankton. They are plantlike in that they make their own food via photosynthesis. However, they are different from plants in several ways, particularly regarding the composition of their cell walls and the presence of accessory photosynthetic pigments. Due to their differences from plants, phytoplankton are assigned to different taxonomic kingdoms. Most phytoplankton are considered to be protists of the kingdom Protista, but some, particularly the cyanobacteria are assigned to the kingdom Monera. Phytoplankton are also known by their more common name, **algae**.

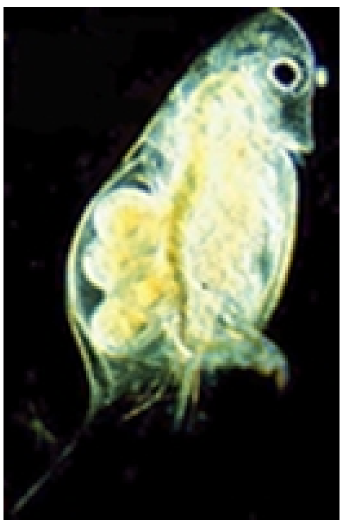
Algae are extremely ecologically important. More than half of the world's photosynthetic organisms are algae. By extension, more than half of the world's atmospheric and dissolved oxygen, a byproduct of photosynthesis, is generated by these microscopic protists and monerans. Algae are also the base of most aquatic food chains. They are highly nutritious and abundant. It is no coincidence that the largest animals in the world, the baleen whales, sift tons of algae from the water as food every day.

Though there are thousands of different kinds of algae, three major varieties live in Lake Roosevelt and will be discussed here. Green algae (Chlorophyta) and diatoms (Bacillariophyta) are both protists while blue-green algae (Cyanobacteria) is a moneran.

Due to their dependence upon sunlight for photosynthesis, algae are usually found relatively close to the







***Volvox* (top) is a colonial species of phytoplankton. *Volvox* is a hollow sphere composed of hundreds or thousands of individual alga cells.**

Diatoms (middle) come in a remarkable array of shapes and sizes. All diatoms are recognizable by their hard, glass-like cell walls.

***Daphnia* is an extremely common zooplankton species in Lake Roosevelt. In winter, they form a chrysalis that allows them to dry up and survive in the absence of water. In this form, *Daphnia* may be carried all over the world by the wind.**

surface of a body of water. Green algae are a very diverse group of algae. They may be single celled, colonial (i.e. small groupings of cells that act as a whole) or multi-cellular. They are not very tolerant of changes in their environment and thus their conspicuous absence is a good indicator of pollution or other environmental disturbance. Easily recognizable by their hard, glass-like shells, diatoms are also an extremely diverse group. Unlike green algae, diatoms are extremely adaptable and are able to survive in a wide range of pristine and disturbed habitats. As monerans, blue-green algae are significantly different from both green algae and diatoms. They lack easily recognizable cell structures (such as a nucleus), and are more closely related to bacteria. However, they do use photosynthesis to make their own food. Blue-green algae are quite hearty in polluted water but are less able to compete with green algae and diatoms in clean water. Thus, an abundance of blue-green algae is a good indicator of pollution.

Only slightly larger in size than phytoplankton are zooplankton. **Zooplankton** are animal-like plankton and are generally referred to as **protozoa**. Protozoa do not have the ability to make their own food and thus are one of the major predators of algae. Protozoa are also quite mobile and can actually control their position in the water, to a degree. There are thousands of different varieties of protozoa, but the most common types found in Lake Roosevelt are the Cladocera and the Copepoda.

Both Cladocerae and Copepodae are very small crustaceans, related to lobsters and shrimp. Both have an external skeleton and move about using specialized appendages on their bodies. One common Cladoceran is *Daphnia*, which are easily cultured and seen under a microscope and thus are a popular purchase for classroom study. Copepods are the single most common type of crustacean in the world. Cladocerans and Copepods may be either herbivorous, feeding exclusively on algae, or carnivorous, feeding on other types of protozoa or cannibalizing members of their own species. Both are vital links in the food chain of a body of water.

Population Ecology

Populations of microscopic organisms are extremely sensitive to environmental conditions that can be affected by pollution. As explained above, population ecology is the study of these changes in environment and how such changes affect the composition of a group of like species. Of particular interest to population ecologists are changes in life history and population growth. Pollution or other water disturbances can affect both of these variables for plankton species in different ways.

The **life history** of an organism includes any activities that influence the reproductive success of individuals and the growth of populations over time. Thus, anything that affects an organisms ability to reproduce will affect a population's life history. Such changes can include death before reaching reproductive age, damage to reproductive organs, an inability to find adequate mates or genetic defects that prevent reproduction, as well as other problems. Aquatic microorganisms like *Daphnia* that inhabit Lake Roosevelt have a highly seasonal life cycle. They begin to grow in the spring, reach maturity in the late summer and begin reproducing by autumn. However, factors such as low water levels, pollution, and abnormally cold spring temperatures can delay early growth in the spring delaying the reproduction season in the autumn. Such delays or a population of *Daphnia* that become reproductively active at different times in the autumn will have a profound effect on the life history as it relates to procreation.

Population growth is another important ecological change that can occur within a population. A single bacterium can reproduce once every 20 minutes under ideal laboratory conditions. Thus, at the end of this time there would be two bacteria, at the close of 40 minutes, there would be four bacteria etc. If this were to continue for a mere 36 hours (a day and a half), there would be bacteria enough to form a layer one food deep over the entire earth! However, that is under ideal conditions. The earth has not been overrun by a thick carpet of bacteria because natural conditions are less than ideal. There are always factors that limit the growth and expansion of organisms. Generally, these limiting factors are nutrients that an organism needs to grow and reproduce.

Blue-green algae, for example, will generally inhabit a lake in benign concentrations. However, from time to time, an influx of phosphate from fertilizer runoff or an overabundance of nitrogen from a sewage spill or septic system will inadvertently or purposefully find its way into a lake. This throws the lake's ratio of nutrients to organisms out of balance. Blue-green algae, as a relative of bacteria, grow and reproduce extremely quickly, and with the influx of nutrients, the lake now has the ability to sustain this rapidly increasing population. The result is an lake that becomes choked with algae, what scientist call an **algal bloom**. The blue-green algae population will continue to increase so long as there is adequate food available. When the food supply is exhausted, the algae will cease reproducing and begin to die off, en masse. The population will have grown extremely quickly only to outstrip its food supply and crash to an extreme low.

Community Ecology

Just as populations of organisms are affected by changes in their environment like pollution, whole communities of organisms can also be affected. And pollution may only be the first step in a chain reaction that changes the community ecology of an ecosystem. Again, community ecology is the interaction between multiple species and the non-living portion of their ecosystem.

Just as an influx of phosphate from agricultural runoff or nitrogen from sewage spill will alter the population ecology of blue-green algae, the resulting algal bloom will profoundly affect the community ecology of the lake. The blue-green algae reproduce extremely quickly and utilize available nutrients at an amazing rate. Other algae like diatoms and green algae are unable to compete with the vigorous blue-green algae for these nutrients and many of these protists die. Those that do not die must compete with the extremely abundant blue-green algae for sunlight. It would make sense that herbivorous protozoa would flourish with so much blue-green algae to eat. However, this is not always the case.

One of the consequences of an increase in algae in the water is a rise in water temperature. Changes in temperature will also result in changes in pH and dissolved oxygen concentrations. The grinding of the biological machinery required for photosynthesis will also raise water temperatures. As zooplankton are sensitive to changes in these three environmental fac-

The small, greenish lake in the foreground is visibly eutrophic while the blue lake in the background is either mesotrophic or oligotrophic. The eutrophic lake may be in the midst of an algal bloom.

tors, fluctuations caused by an algal bloom will usually hinder the life cycle of protozoa, even though there is an overabundance of food for them to consume.

Algal blooms also produce a cocktail of dangerous toxins. These toxins have a devastating effect on animal populations in the lake. Microorgansims and fish alike may be killed or stricken with sickness, either of which will impact their life history. Fish may also be killed by the fluctuating pH and dissolved oxygen levels and the increase in temperature caused by the algae. With the increased mortality of less competitive algae, protozoa, and fish and their resultant decomposition, a new influx of nutrients (particularly nitrogen) are added to the water, sustaining the bloom further.

Algal blooms also impact animals dependent upon aquatic organisms for food and, in this way, the entire food chain is affected. A **food chain** is the interconnected producer/herbivore/prey/predator relationship between organisms with different life histories. **Primary producers** are plants and algae that convert water, carbon dioxide and nutrients in complex carbohydrates. **Primary consumers** feed almost exclusively on primary producers. Thus, primary consumers are the herbivores of the animal world. In a lake, primary consumers are protozoa like *Daphnia*. **Secondary consumers**, the next step in the chain, are animals that eat primary consumers and little else. In a lake, secondary consumers are carnivorous protozoa, some fish and other macroinvertebrates. **Tertiary consumers** eat secondary consumers. Large fish, eagles, bears and humans are all tertiary consumers. It should be evident that any disturbance to the food of one level of organism will have repercussions to all of the organisms above them in the food chain. Hence, an algal bloom will not only kill less competative algae, as well as protozoa and fish, but it will also affect the food supply of eagles, bears and humans. Systems of this level of complexity are a hallmark of the study of ecological communities.

Lake Productivity

Scientists categorize lakes based upon a suite of characteristics that include nutrient content (particularly nitrogen and phosphorus), dissolved oxygen levels and the abundance of photosynthetic organisms (plants or algae). Lake productivity is not synonymous with lake health as a lake with a low level of production is perfectly healthy for plants and animals that are adapted to living in its waters.

A **eutrophic** lake is characterized by high concentrations of nitrogen and phosphorous resulting in high productivity. Due to the high level of productivity, dissolved oxygen levels tend to fluctuate greatly and water temperatures are high. Eutrophic lakes are generally shallow and have a frequent incidence of algal blooms, therefore, such lakes often have a slimy appearance and can often smell like moist decay. Slightly or moderately eutrophic water can be healthful and support a complex community of plant and animal life, though fish that require high levels of dissolved oxygen (e.g. trout, salmon) are absent. More adaptable fish, like carp, suckers, perch, catfish, and bluegill will all tolerate eutrophic conditions without adverse effects. Eutrophic lakes are generally undesirable for drinking or swimming.

Mesotrophic lakes have moderate concentrations of nitrogen and phosphorous resulting in significant productivity. Though significant, the productivity levels are much lower than in a eutrophic lake and so dissolved oxygen levels are slightly higher and more constant. Algal blooms are less frequent in mesotrophic lakes when compared to eutrophic lakes. Mesotrphic lakes can support a very diverse community of life which may include a mix of oxygen-sensitive fish like trout and more adaptable species like carp. However, like eutrophic waters, mesotrophic waters are generally undesireable for drinking (though they would be fine for swimming).

Oligotrophic lakes have very low concentrations of nitrogen and phosphorous and therefore are generally not very productive. Because there are very few plants and animals in an oligotrophic lake, water temperature is cool and the dissolved oxygen concentration is generally very constant and quite high. Because of the overall paucity of life in the water, these lakes are usually a deep blue, rather than green. Because oligotrophic lakes are not very productive, most of the nutrients that sustain fish must come from outside the lake system. The high dissolved oxygen levels are ideal for trout and minnows, but little else can live in these lakes. The cool, clean water is ideal for drinking and swimming.

Lesson Comprehension Questions

1. What are the three branches of ecology and how do they differ from one another?

2. What are plankton? What are the two general types of plankton? How are these two types of plankton different from one another?

3. How does an algal bloom affect a lake's *community* ecology?

4. Scientists characterize lakes based upon their productivity. What are the three types of lakes and name two measures of productivity that scientists use to categorize lakes? Do you have any lakes in your community that you could categorize based upon its level of productivity? If so, what are they?

5. How does a lake's level of productivity affect the types of fish and other animals that can live there?

6. If you were to dig your own lake in your backyard and fill it with water, what type of lake would it be, based upon it's productivity? Why? If you wanted to stock it with fish, what type of fish might survive in such a lake?

Crater Lake in southern Oregon is a classic oligotrophic lake. It is a deep lake with clear, blue water and a high concentration of dissolved oxygen.

Trip Logistics

Preparations for the Floating Classroom trips begin more than six months before the trips. Unfortunately there are not enough trips available each year for all interested schools to participate and so a first come-first served policy was born. If a school was not able to reserve a spot on a Floating Classroom trip the previous year, the following year they have the privilige of choosing their trip date first. After the National Park Service reserves the houseboats in April for Floating Classroom trips scheduled for October, teachers who's classes were excluded from the program last year are contacted and given their first choice of sailing dates. Once those schools have signed up (if interested), the remainder of the trips are scheduled on a first come, first served basis. Teachers will receive a letter from the National Park Service alerting them of the date and time that we will begin taking reservations. Reservations will not be taken before that date. On the day we begin taking reservations, phone calls will be accepted by the park's education specialist or Floating Classroom coordinator in the order in which they are received (leaving a message on voicemail ***will*** suffice for a reservation). Once the trips are full, schools may be put on a waiting list in the event of an unexpected cancellation. If no schools cancel, then the waiting list becomes the priority selection list for the following year.

In the weeks leading up to your school's trip, begin to review this preparation guide and budget some class time or homework time for introducing the students to the concepts contained in this booklet. You may choose to add your own exercises or experiments to this informationor to tailor this information to other topics you are teaching. Even if you choose not to spend class time addressing some of the topics in this preparation guide, please, at the very least, make photocopies of the introductory information and lesson comprehension questions in lessons 1-3 and assign each lesson as homework. These three lessons are the foundation upon which the entire Floating Classroom experience is built. Without this knowledge, your students will not get as much from their Floating Classroom trip.

There are some logistical items you should also begin considering during the weeks leading up to your trip. Each Floating Classroom trip will be led by a minimum of two National Park Service rangers, but the rangers will need your help with activities and controlling your class. Thus, in addition to yourself, you will need to find a willing, opposite sex chaperone to accompany your class. This person may be another teacher or even an interested parent. It is extremely helpful if the chaperone is interested in science and is willing to take an active role in helping the students with their experiments and activities.

In some cases, there are more students in a class than can fit on our two houseboats (20 students total). If this is the case, then you must find a way to thin your class down to 20 students. There are several ways of doing this. Some students may be disinterested in the program. Some students may be having disciplinary problems that could disqualify them from the program. One of the most successful means of awarding slots on a trip is by merit. Included in Appendix C is a pre-trip student evaluation that focuses on the information in this preparation guide. Though you are encouraged to administer this evaluation as a means of gauging student knowledge about Floating Classroom basics, it can also be used as a pass-fail ticket to participation (with a grade of 70 being required to participate).

Some teachers may find themselves in the opposite situation; not having anywhere near 20 students. There are several smaller schools in the area that participate in the program that have had far fewer than 20 students participate in the program in the past. Having fewer than 20 students is not a problem; the trip will still occur. However, due to the expenses involved in the program, some schools may wish to consider the possibility of combining with another school. Combining will allow you to split your school's gas and oil costs with another school. The names and phone numbers of all participating schools are listed in Appendix D. Please contact the Lake Roosevelt National Recreation Area education specialist or Floating Classroom coordinator at 509/633-9192 ext. 12 if you think you may want to split your trip with another school.

Paperwork is a time-consuming but necessary step in preparing for the program. Copies of the necessary forms can be found in Appendix A. Briefly, the principal or school district superintendent must sign the participation agreement in order for your school to participate. The National Park Service pays the rental fee for the boats, but each school is responsible for purchasing the gas and oil for their trip. Thus, each school will be required to bring a purchase order for a pre-determined amount, payable to Roosevelt Recreational Enterprises. The National Park Service will contact you in advance of your trip with a cost estimate for gas and oil. In addition, each student and their parent or guardian must agree to and sign the student permission form. All of these forms should be brought with you on the day of your trip. We cannot leave the dock without them. We will also need a list of all of the students and teachers/chaperones, divided into groups by sex. These four forms (principal/superintendent agreement, student permission form, purchase order, and passenger list) are the only forms that the National Park Service or Roosevelt Recreational Enterprises require for a class to participate in the Floating Classroom program. Your school may require other internal forms to insure that all liability questions have been answered.

Each school must arrange for transportation to and from the start/end point of each program. The National Park Service will inform you of the start/end point of your trip. In the past, schools have used busses, parental carpools, or even borrowed vehicles from community service organizations to transport them to and from the marina.

Floating Classroom students take a hike and learn how environmental disturbances can affect water quality.

Teachers should also be aware that you and your students will be absent for two days of school. Students should make arrangements for missing class and getting their assignments. It is perfectly normal for students to be assigned homework to do on a Floating Classroom trip. Indeed, if other teachers want to assign a project that relates to the Floating Classroom experience, all the better (e.g. one group was assigned to keep a journal of their onboard activities by their English teacher, another were told to keep a journal in preparation for composing an essay for a grade upon their return to class, etc.). Teachers should make arrangements for a substitute for the two days they will miss.

Finally, schools will be responsible for planning and preparing their own meals on each trip. These meals should include one breakfast, two lunches and one dinner. Breakfast and lunch should both be fairly simple as we will have to fit both of them into our activity time. Most schools find that cereal with milk, donuts, or pastries all make for a good, quick breakfast. Sandwiches are great for lunch—they can either be made ahead of time or built from scratch on board. Dinners can be more elaborate. Each boat is equipped with pots and pans, a gas stovetop and oven, and a barbecue grill. Most schools choose to grill hamburgers and hot dogs. Remember, the more plates, pots and pans that are dirtied the more there will be to clean up after eating (this is especially true for breakfast, since all breakfast messes must be cleaned up by the time we begin our first activity of the day at 8:00AM). Many schools also bring several gallons of drinking water with them; though the houseboats do have their own potable water system, the many participants in past years have found that the water does not taste very good.

Come prepared for foul weather. We have had beautiful, sunny trips and we have had miserable, rainy trips. Even snow is not unheard of. Everyone should pack light but as warmly as possible. A warm sleeping bag or heavy blanket and a pillow is a must. Rain gear is also highly recommended. Bring some sturdy shoes, as well, since there will be some hiking on shore.
On the day of your school's Floating Classroom trip, plan upon arriving at the marina no later than 10:00AM. ***Be sure you have the principal/superintendent agreement, student permission form, purchase order, and passenger list with you when you arrive.*** The students will load up the houseboats, National Park Service rangers will orient the entire group to the boats and explain the rules, the students will be split into two groups (one for each houseboat), and the trip will begin.

If any problems or questions arise while planning for your school's Floating Classroom trip, please do not hesitate to contact Lake Roosevelt National Recreation Area's education specialist at 509/633-9192 ext. 12.

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Appendix A

Liability and Permission Forms

LAKE ROOSEVELT NRA FLOATING CLASSROOM
PARTICIPATION AGREEMENT

The Lake Roosevelt NRA Floating Classroom is a unique learning laboratory coordinated by the National Park Service, Lake Roosevelt National Recreation Area. The Floating Classroom consists of two 52-foot houseboats rented from Roosevelt Recreational Enterprises and outfitted with a full range of water quality and aquatic environment monitoring equipment. During a two-day overnight course, students travel to selected test sites on the lake, combining active hands-on testing and data gathering exercises with classroom study of complex water resource issues. Though there is no direct charge for the program, participating schools are responsible for incidental expenses and obligations listed below.

THE PARTICIPATING SCHOOL:

1. has adequate liability insurance for an overnight houseboat excursion on Lake Roosevelt, including coverage for damage or injury (including death) to participating students and school staff or property suffered on, in or about the houseboats by reason of the school's participation in the Floating Classroom program.

2. provides transportation for students and school staff to and from the designated departure and arrival marina site.

3. pays for all gasoline and oil used by the houseboats upon receipt of the invoice from Roosevelt Recreational Enterprises. Each school will present a purchase order to Roosevelt Recreational Enterprises for issuance of an invoice.

4. has classes plan, purchase, pack, prepare and clean up after their own group meals, to include lunch and dinner on the first day and breakfast and lunch on the second day. The houseboats are equipped by Roosevelt Recreational Enterprises with cooking and eating utensils.

5. classes leave the houseboats as clean as when they were boarded. Cleaning supplies and equipment are provided.

6. provides at least two adults (a teacher and an opposite sex chaperone) to accompany and supervise the participating students, and provides for any necessary substitute teachers during the absence of the participating teachers.

7. obtains signed parental permission forms for all participating students, including any necessary permission for absence from classes and arrangements for assignments.

8. reviews the Floating Classroom safety and behavior guidelines with all participating students, and obtains student and parental signatures on guideline forms.

9. agrees that the National Park Service and Roosevelt Recreational Enterprises are not responsible for any property left stored, lost or transported by students or school staff in, on or upon houseboats before, during or after the Floating Classroom program.

10. understands that National Park Service assumes responsibility for the operation of the houseboats and accordingly, the United States will be liable for the negligent acts of its employees acting within the scope of their employment to the extent, and as allowed by, the Federal Tort Claims Act, 28 USC 2674 et seq.

Participation in the Floating Classroom program is subject to the terms and conditions set forth above. The official school representative has read and agrees to the same.

Agreed:______________________________ ______________________________
Signature Date

______________________________ ______________________________
Title School

LAKE ROOSEVELT NRA FLOATING CLASSROOM
STUDENT PERMISSION AND WAIVER OF LIABILITY

I, ____________________________ understand and will abide by the following rules and guidelines for the National Park Service Floating Classroom program.

1. The student will notify both the teacher and the National Park Service staff of any preexisting medical conditions or medications that are taken on this field trip.

2. The student will understand that the two boats are to be divided into girls and boys sleeping quarters. There will be no crossing from boat to boat after 10:00PM. If weather permits, students may sleep on the top deck of the houseboats. No one will be allowed to sleep on shore or any other place other than their designated houseboat. Quiet hours are from 10:00PM to 6:00AM.

3. All students will participate in meal preparation and/or cleanup, and the final boat cleanup at the end of the trip.

4. The student will come prepared for all types of weather conditions. It is strongly recommended that students bring sleeping bags and layered clothing. Keep in mind that there is little space on the houseboats, so there should be no more than one extra set of clothes per trip. All accessories should be kept at home.

5. Televisions, radios, tape players, CD players or other music players are not allowed on board.

6. Horseplay or other disruptive behavior will not be tolerated.

7. The use of tobacco products, alcohol or drugs is ***strictly prohibited***.

8. Instructions or directions of National Park Service staff must be followed.

9. If any of the above guidelines are abused or broken, it may result in the immediate cancellation of the trip and the immediate return to the marina for the ***entire group***.

I have read, understand and agree to the conditions listed above.

____

____

Student Date Parent/Guardian Date

LAKE ROOSEVELT NRA FLOATING CLASSROOM
PARTICIPANT LIST

The following students, teacher and chaperone will be passengers on one of the two Roosevelt Recreational Enterprises houseboats rented by the National Park Service for the Floating Classroom Program:

Female Students	Male Students
1.	1.
2.	2.
3.	3.
4.	4.
5.	5.
6.	6.
7.	7.
8.	8.
9.	9.
10.	10.
11.	11.
12.	12.
Female Chaperone:	Male Chaperone:

Appendix B

Visual Aids

Table 1-A: Relative Proportions of Water on Earth

(from Rivers: Earth Science, Southern Illinois University1998)

Body of Water	Percent of Total	Proportion of Four Liters of Water
Oceans	**97.2%**	**3,880mL**
Icecaps/Glaciers	**2.1%**	**88mL**
Groundwater	**0.62%**	**25mL**
Freshwater Lakes	**0.017%**	**17 drops**
Inland Seas/Salt Lakes	**0.008%**	**8 drops**
Atmosphere	**0.001%**	**1 drop**
Rivers	**0.0001%**	$^{1}/_{10}$ drop
Total	99.9461%*	

*The remaining water is found in plants, animals and the upper layer of soil.

Figure 1-A: The Water Cycle

(from Rivers: Earth Science, Southern Illinois University1998)

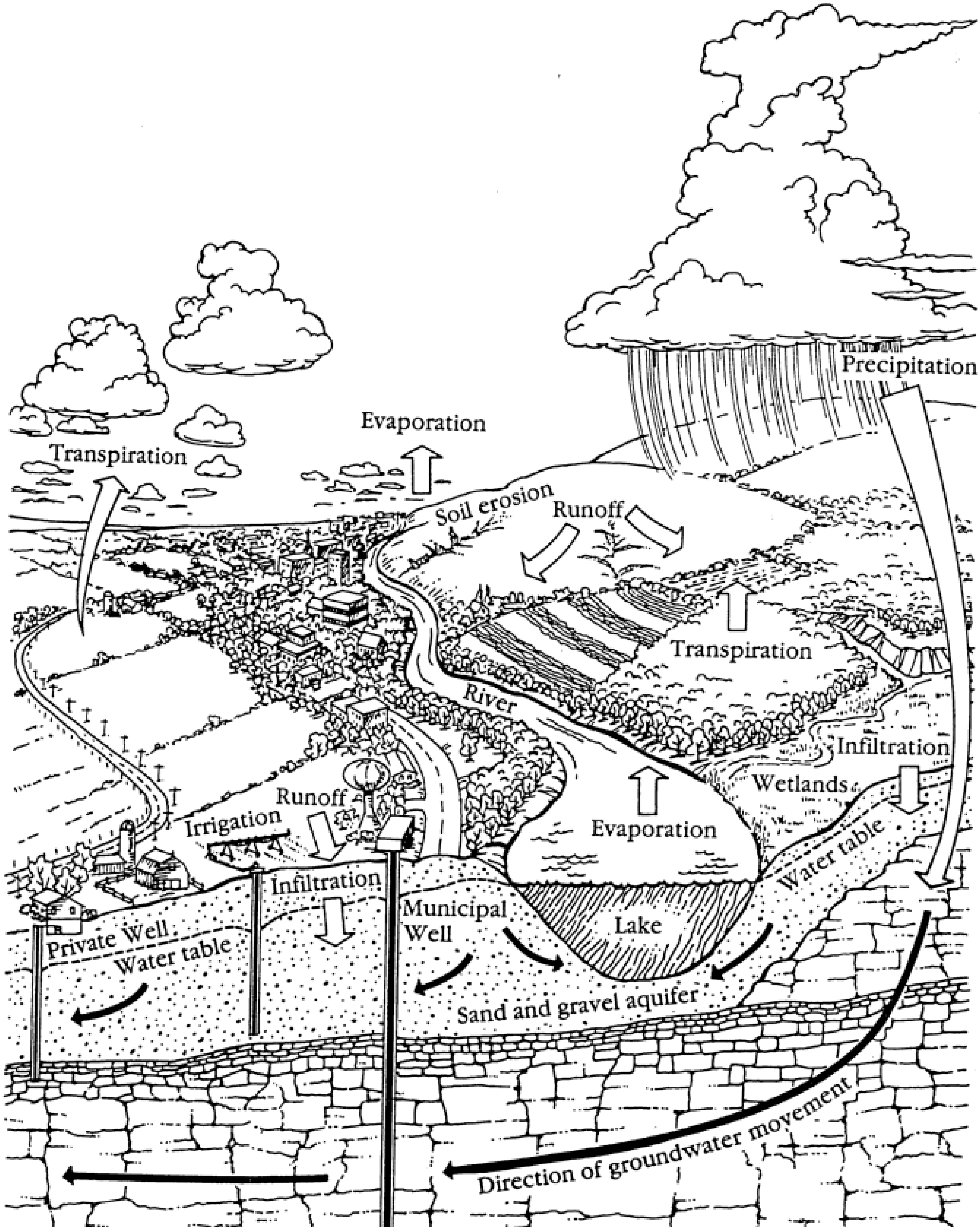


Figure 1-B: The Water Cycle (alternate)

(from Biology, Neil Campbell, Benjamin/Cummings Company, 1993)

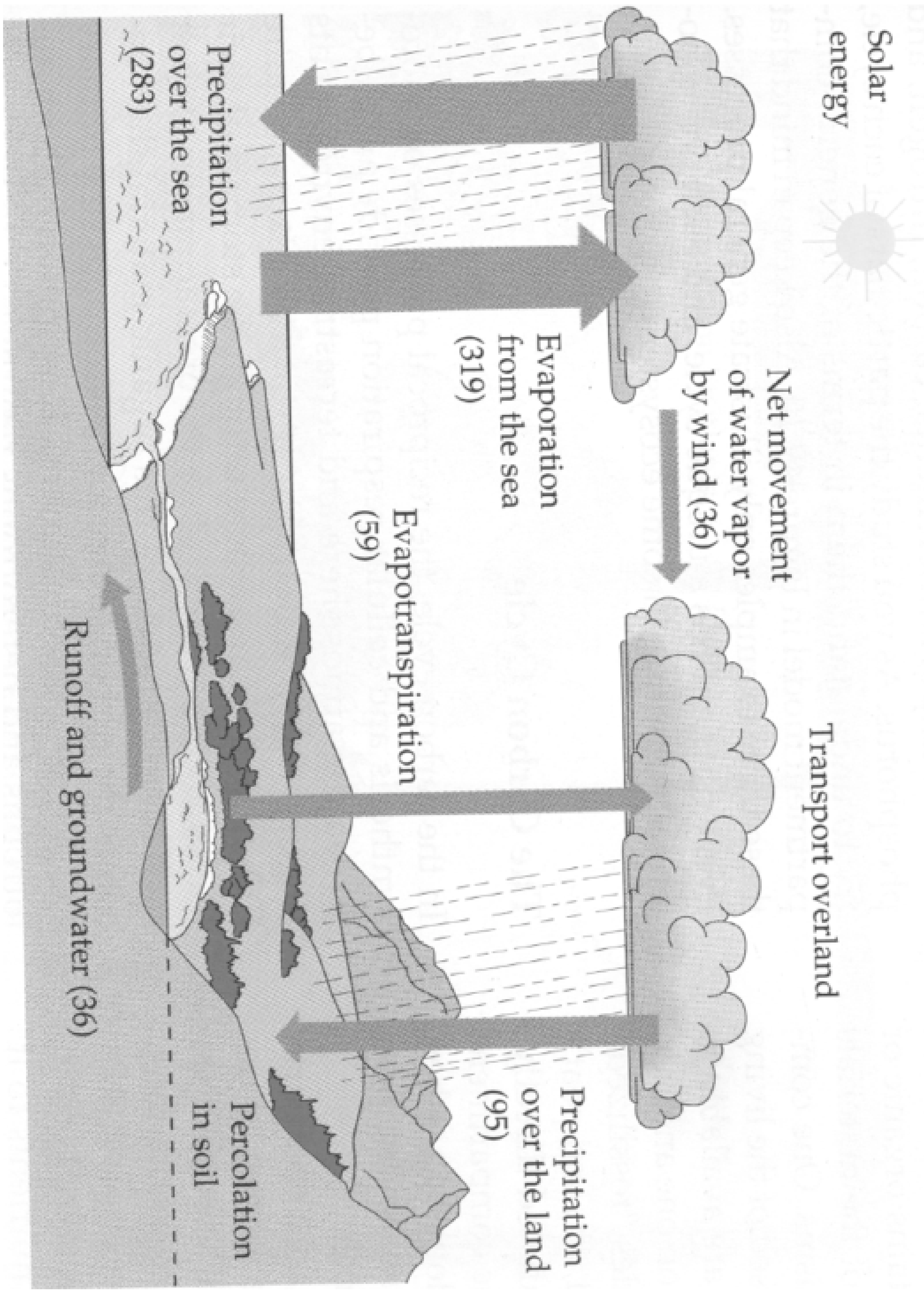


Figure 1-C: The Lake Roosevelt Watershed

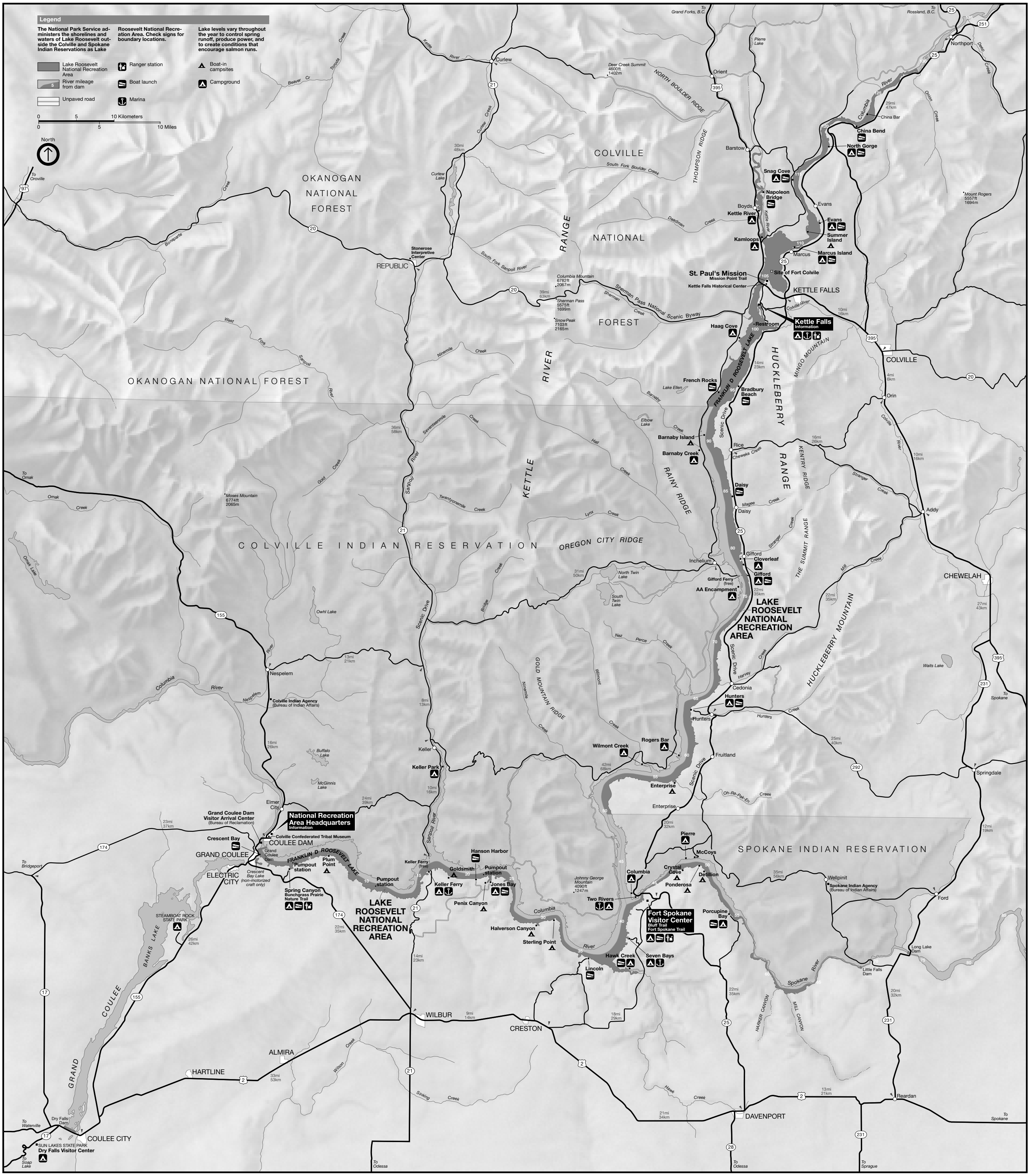


Figure 1-D: How Many Watersheds? (Arabian Peninsula)

Figure 2-A: The Phosphorus Cycle

(from Biology, Neil Campbell, Benjamin/Cummings Company, 1993)

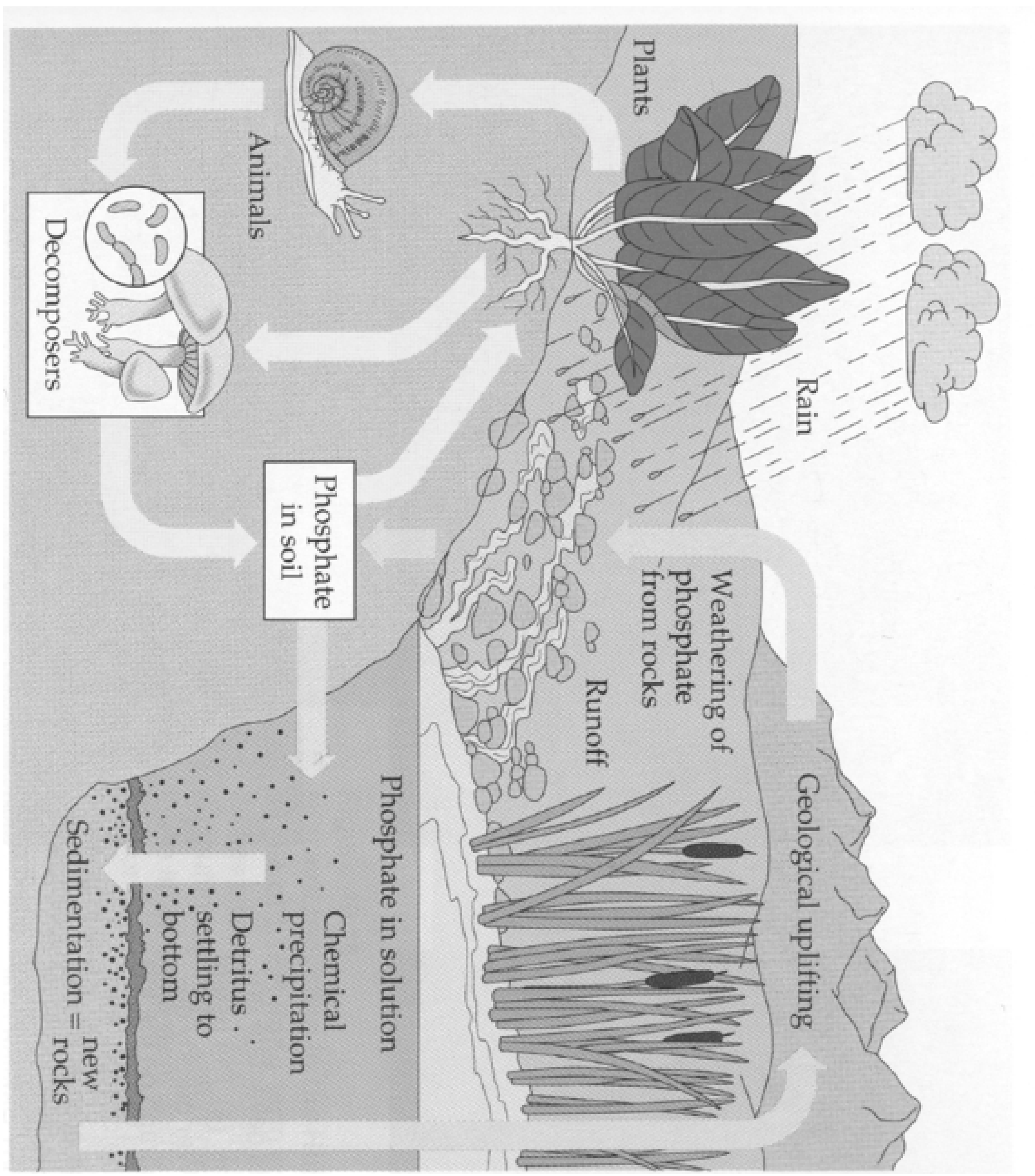
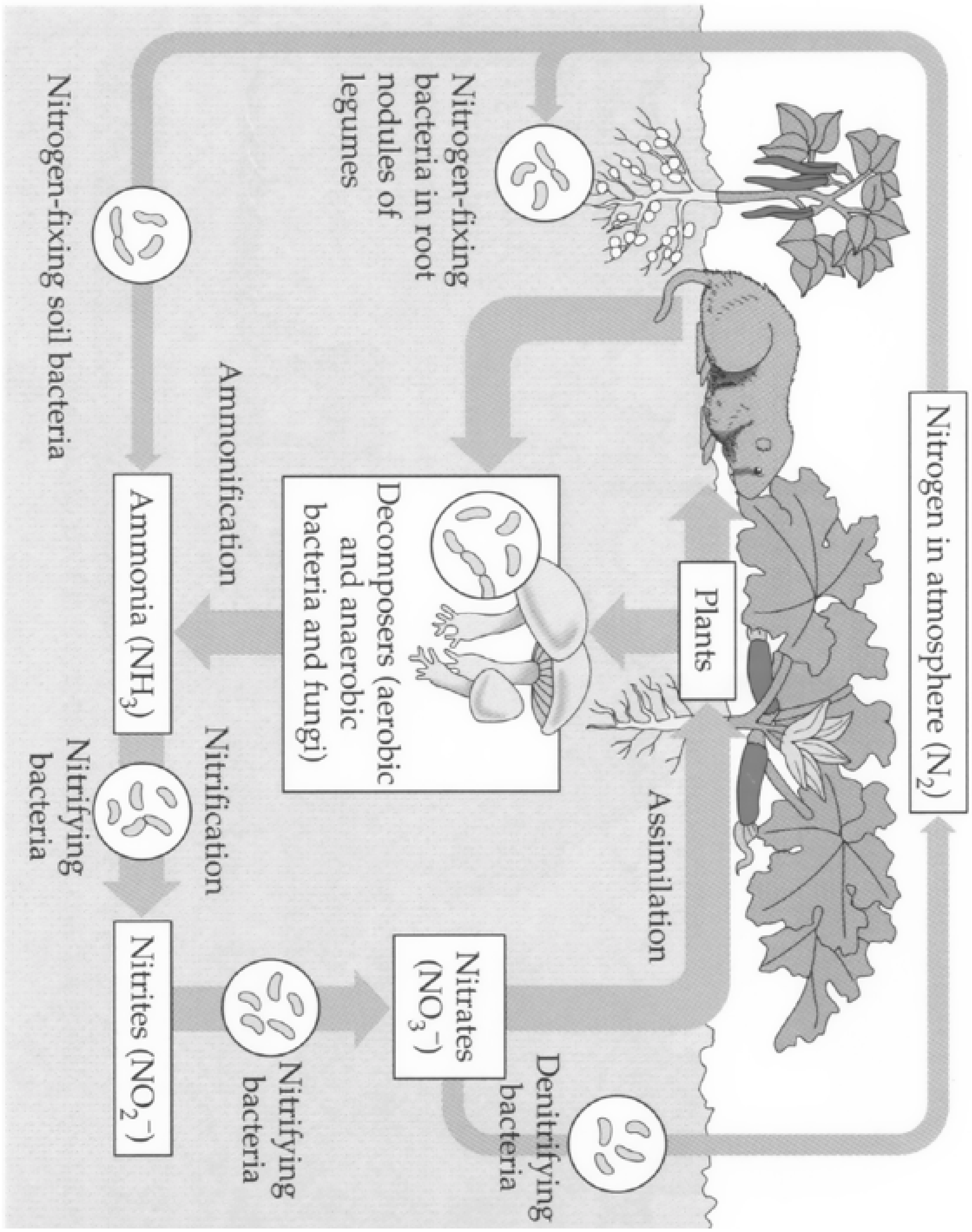


Figure 2-B: The Nitrogen Cycle

(from Biology, Neil Campbell, Benjamin/Cummings Company, 1993)



Appendix C

Pre-Floating Classroom Student Evaluation

Answer Key:

1. B
2. B
3. C
4. A
5. C
6. D
7. D
8. A
9. C
10. B
11. C
12. B
13. C
14. B
15. D
16. B
17. A
18. C
19. A
20. B

Name:

Date:

1. The water cycle (a.k.a. the hydrological cycle) is
A. The energy saving wash cycle on your home dish washer
B. All of the atmospheric and environmental factors that can impact the biology, chemistry, abundance and distribution of water
C. The cycling of water within a larger body of water like a lake or ocean
D. The only process in nature in which water flows uphill

2. How much of the water on planet Earth is contained in oceans?
A. 3%
B. 97%
C. 80%
D. 47%

3. Solar energy excites water molecules and causes evaporation from bodies of water and ____________ from the pores in the leaves of plants.
A. Infiltration
B. Precipitation
C. Transpiration
D. Promulgation

4. Water is soaked into the soil and becomes part of an aquifer through the process of ___________.
A. Infiltration
B. Precipitation
C. Transpiration
D. Promulgation

5. Divides and drainage basins are all characteristics of a ____________.
A. Province
B. Plateau
C. Watershed
D. Cloud formation

6. Water samples on a Floating Classroom trip will be collected using a _______ sampler.
A. Secchi Disk
B. Conductivity Meter
C. Sample Bucket
D. Van Dorn

7. Which of these factors can affect the dissolved oxygen concentration in a lake or river?
A. Waterfalls
B. Temperature
C. Boat Propellers
D. All of the above

8. Rainwater is naturally ___________.
A. Acidic
B. Basic
C. Neutral

9. Turbidity is the measure of
A. The ability of water to conduct an electrical charge
B. The amount of fish in a particular body of water
C. The amount of particles suspended in a body of water
D. The amount of chemical compounds dissolved in a body of water

10. True of False: If you were to fill you bathtub up with pure, distilled water, got in the tub and dropped your hair dryer in the tub with you, you would be electrocuted. (DO NOT TRY THIS AT HOME!)
A. True
B. False

11. Why is it important to monitor levels of orthophosphate in a lake?
A. Because you must monitor orthophosphate levels so that you know when it is OK to add more orthophosphate to the lake.
B. Because orthophosphates are toxic to plants and animals.
C. Because orthophosphates are a limiting factor in plant growth and if there is too much orthophosphate, rampant plant growth will result
D. Because there is too little orthophosphate in the world today due to internal combustion engines

12. Which of these compounds is not utilized by plants in the synthesis of proteins?
A. Ammonia Nitrogen
B. Atmospheric Nitrogen
C. Nitrates
D. Nitrites

13. Ecology is
A. The study of money and world economies
B. The study of plants
C. The study of the interactions between all organisms and their environment
D. The study of animals

14. This branch of ecology is concerned with how environmental factors impact organisms of the same species that live in a particular geographic area.
A. Organismal Ecology
B. Population Ecology
C. Community Ecology
D. Ecosystem Ecology

15. Plant-like plankton are collectively referred to as
A. Zooplankton
B. Cyanobacteria
C. Protozoa
D. Phytoplankton

16. The rampant, unrestrained growth of certain types of algae (like blue-green algae) is called a (an)
A. Outbreak
B. Algal Bloom
C. Spurt
D. Mistake

17. True or False: The food chain is the interconnected plant/herbivore/ prey/carnivore relationship between organisms with different life histories.
A. True
B. False

18. _________ __________ are the base of the food chain upon which all other organisms are dependent.
A. Primary consumers
B. Tertiary consumers
C. Primary producers
D. Fungal decomposers

19. __________ lakes are generally green, have relatively high concentrations of nitrogen and phosphorus and low concentrations of dissolved oxygen.
A. Eutrophic
B. Oligotrophic
C. Mesotrophic

20. __________ lakes are generally clear and blue with low concentrations of nitrogen and phosphorus and high concentrations of dissolved oxygen.
A. Eutrophic
B. Oligotrophic
C. Mesotrophic

Appendix D

Participating Schools and Teachers

Columbia High School
Deb Berg and Tom Cools
PO Box 7
Hunters WA 99137
Phone: 509/722-3311

Colville High School
Jim Cristian
154 Hwy 20E
Colville WA 99114
Phone: 509/684-7800

Creston High School
Jeff Boyd
PO Box 17
Creston WA 99117
Phone: 509/636-2721

Chewelah/Jenkins High School
Jim Biancardi
PO Box 138
Chewelah WA 99109
Phone: 509/935-8533

Davenport High School
Rawleigh Fisk
800 6th St.
Davenport WA 99122
Phone: 509/725-4021

Inchelium High School
Sue Dean Langlois
PO Box 285
Inchelium WA 99138
Phone: 509/722-6181

Kettle Falls High School
Jono Esvelt and Marcus Morgan
1275 Juniper St.
Kettle Falls WA 99141
Phone: 509/738-6388

Lake Roosevelt High School
Ralph Rise and Eric Lampi
500 Civic Way
Coulee Dam WA 99116
Phone: 509/633-1442

Mary Walker High School
Dennis Kiefer
PO Box 159
Springdale WA 99173
Phone: 509/258-4533

Northport High School
Karma Goodwin and Jim Goodwin
PO Box 180
Northport WA 99157
Phone: 509/732-4870

Wellpinit High School
Tom Varner
PO Box 390
Wellpinit WA 99040
Phone: 509/258-4535

Wilbur High School
Jason Maioho
PO Box 1090
Wilbur WA 99185
Phone: 509/647-5602